1,191,633

PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements in Artificial Limbs and Splints

We, J. E. HANGER AND COMPANY LIMITED, a British company, of Roehampton House, Roehampton Lane, London, S.W.15, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention concerns improvements in artificial limbs and splints and is directed to the provision of such apparatus whose performance is enhanced by the introduction of joint movement control derived from electric pulses or signals transmitted by a patient's brain to his muscle fibres.

Medical and prosthetic procedures have recognised and used electromyograph signals that are associated with muscle stimulus to control, for example, the opening and closing of an artificial hand. This signal originates in the conscious or autonomic processes of the brain and is transmitted to the muscle fibres through the appropriate nerve system and results in a measureable variable electrical potential difference over the muscle surface. This can be picked up by electrodes over the outer surface of the skin and amplified sufficiently to energise an electric actuator which can operate any suitable device designed to mechanically control the prosthesis in accordance with the physical demands of the amputee.

A direct link can now be created between mental conscious or autonomic stimuli and electro-mechanical functional controls in a prosthesis and thus provide a more natural replacement of anatomical function which has been lost by reason of amputation or other surgical treatment.

Paralysis does not inhibit the myo-electric process as outlined, and orthopaedic appliances can be designed with similar controls that can be operated by mental stimuli.

One of the chief applications of the invention is in the improvement of gait control or stability of the knee and or ankle joints of a lower limb amputee or of similar joints in splints or "irons" of victims of paralysis.

According to the invention we provide artificial legs or splints in which the degree of freedom of movement of the joints is controlled or inhibited by restrictive means operated by mechanical-electric actuators movable in accordance with the intensity of electromyograph signals, the said legs or splints including electrodes for contacting the patient's skin to detect such signals.

An hydraulic control operated in accordance with the invention will now be described as an example.

In British Patents Nos. 762,695 and 886,569 are described knee joints for above-the-knee artificial legs in which a controlled resistance to flexure is applied by an hydraulic damping device over selected angular displacements of the joint.

The damping device particularly described and illustrated in both Patents includes a cylindrical housing fixed to the thigh portion of the leg and a rotary vane carried on a shaft locked to the shin portion. A web extending from the inner wall of the housing and making a close fit with the vane shaft divides the housing into two chambers; while a needle valve is used to regulate flow of hydraulic fluid from one side of the web to the other.

In the artificial knee joint of the present invention such a needle valve is replaced by a spool type or rotary valve whose condition determines the degree of restriction to free flow through the web, the outer edge of the vane being in sealing contact with the inner wall of the housing throughout its movement. When the valve completely obturates a passage through the web, the thigh and shin parts of the leg are either locked against relative movement or such movement is restricted in accordance with the setting of a by-pass valve.

Electrodes are fitted in the socket of the

thigh portion of the limb so as to contact the skin of the patient.

Two pairs of electrodes are arranged over appropriate muscles.

A battery and amplifier housed in the lower part of the thigh portion of the limb are used to transmit actuating signals derived from the appropriate muscles to a solenoid or the like by which the valve is shifted.

Fine adjustment means are provided to limit the movement of the valve in both directions.

On operation of the solenoid, the valve may be arranged to close fully on the attainment of full flexure and to open fully when the knee joint is fully extended.

By adjusting the amount of valve movement required for a particular gait pattern of an amputee in conjunction with the myo-electric signals transmitted through the flexor and extensor muscles, gait can more nearly approach natural function.

It is emphasised that the above description of an hydraulic control is exemplary only and that the invention can be applied to many other forms of gait control means. It may, for example, be used to apply a restrictive load to actuate a mechanical or magnetic brake.

It is also to be noted that the invention lends itself to what are termed stabilizing controls for either artificial limbs or splints. Should a patient stumble as a result of walking on bad terrain or tripping, it may save a dangerous fall if the joint or joints of an artificial limb or splint are immediately locked so as to provide a support for recovery of balance. The autonomic process of the brain of the patient and the consequent electrical signal may be used to cause an overriding locking of the joint or joints at any degree of flexure.

The invention is illustrated schematically in the accompanying drawings, in which:

Fig. 1 is a side elevation of an artificial leg.

Fig. 2 is a section through one form of knee flexure control.

Fig. 3 is a side elevation of a knee joint employing an hydraulic cylinder and piston control.

Fig. 4 is a diagrammatic representation of an electro-magnetic restrictor usable with the controls of Figs. 2 and 3.

Fig. 5 is a section of a mechanical brake control for a knee joint.

Referring first to Fig. 1 there will be seen the thigh portion 1 of an artificial leg, a shin portion 2 and a knee joint pivoted about an axis 3.

The stump 4 of an amputee is shown with a typical pair of skin contact electrodes 5 and 6 connected to an amplifier 7 powered by a battery 8. These last two items are shown housed within the lower part of the thigh portion 1 with electrical connections to the control valve 9 of a knee joint flexure restrictor 10.

One form of restrictor shown in Fig. 2 has a cylinder 11 fixed to the thigh portion of the artificial leg in which a rotary vane 12, carried by a central shaft 13 fixed to the shin portion, operates. Resistance to flexure is controlled by a rotary valve 14 operating in a by-pass passage through a dividing segment 15. The segment 15 extends from the wall of cylinder 11 to shaft 13 and with vane 12 divides the cylinder into two chambers. An electrical valve operator 16 operates in response to amplified signals from the skin-contacting electrodes.

The cylinder and piston form of restrictor shown in Fig. 3 has its cylinder 17 housed within the shin portion of an artificial leg and its piston rod 18 connected to the thigh portion. Flow through a by-pass tube 19 is controlled by a valve 20, which may be a rotary valve such as shown in Fig. 2 or a spool valve operated by a valve operator such as 16 (Fig. 2) or an electro-magnetic orifice restrictor as shown in Fig. 4.

The restrictor of Fig. 4 is of the kind in which a ferro-colloidal or other magnetic fluid is caused to coalesce due to the switching on of a magnetic field in which it is situated and derived from windings 21, surrounding a through passage 22 for such a fluid.

Current to the windings can be switched on or off in relation to the strength of electromyograph signals. This orifice restrictor could be used in place of the rotary valve shown in Fig. 2.

The mechanical brake shown in Fig. 5 has a drum 23 attached to the shin portion of an artificial leg and a band 24 fixed to the thigh portion. A lever 25 operates to tighten or slacken the band 24 as actuated by a solenoid or like electrical actuator 26 which is switched on or off in relation to the strength of electromyograph signals.

WHAT WE CLAIM IS:—

1. Artificial legs or splints in which the degree of freedom of movement of the joints is controlled or inhibited by restrictive means operated by mechanical-electric actuators movable in accordance with the intensity of electromyograph signals, the said legs or splints including electrodes for contacting the patient's skin to detect such signals.

2. Artificial legs according ot Claim 1 in which a battery and amplifier are housed in the artificial leg.

3. Artificial legs according to Claim 1 in which the restrictive force is applied hydraulically and as determined by the position of a valve controlled by amplified electromyograph signals derived from the patient's skin.

4. Artificial legs according to Claim 1 or

Claim 2 in which the restrictive force is derived from a brake applied mechanically by an electrical actuator powered by amplified electromyograph signals derived from the patient's skin.

5. Artificial legs according to Claim 3 in which the valve comprises an electromagnetic restrictor.

6. Artificial legs or splints constructed and arranged substantially as described herein and shown in the accompanying drawings.

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1191633 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

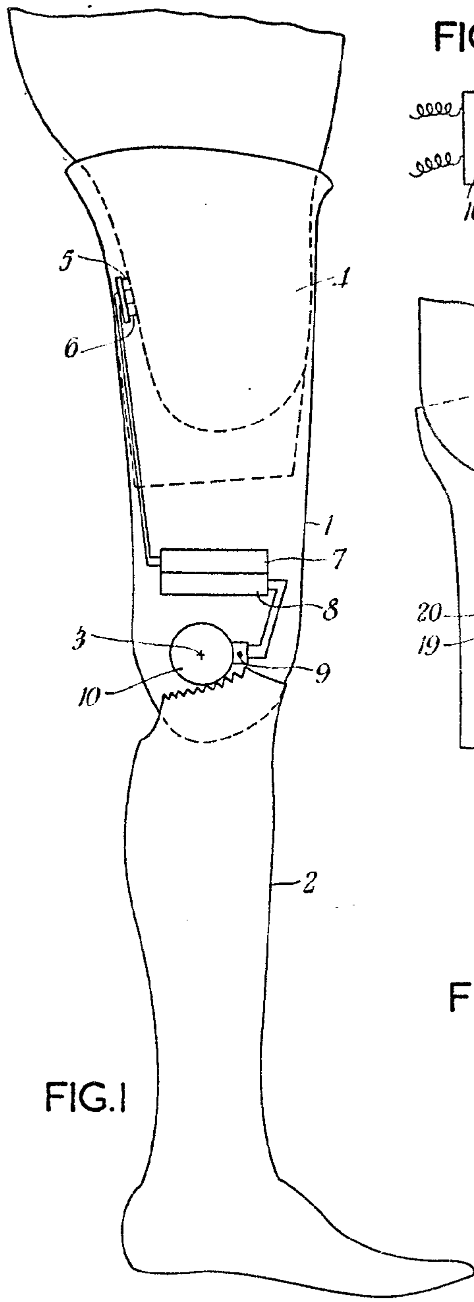

FIG.1

FIG.2

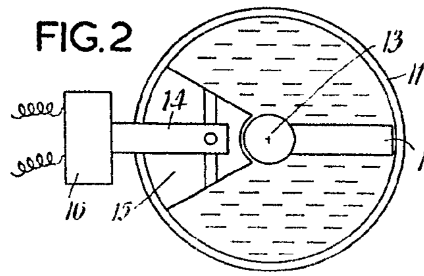

FIG.3

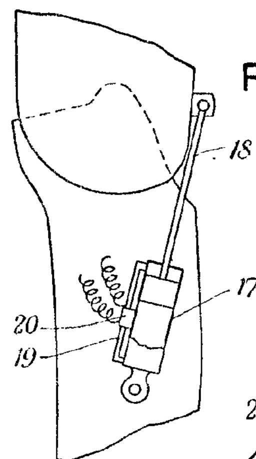

FIG.5

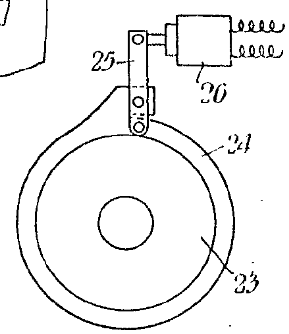

FIG.4